Advanced Networking: Network Address Translation (NAT)

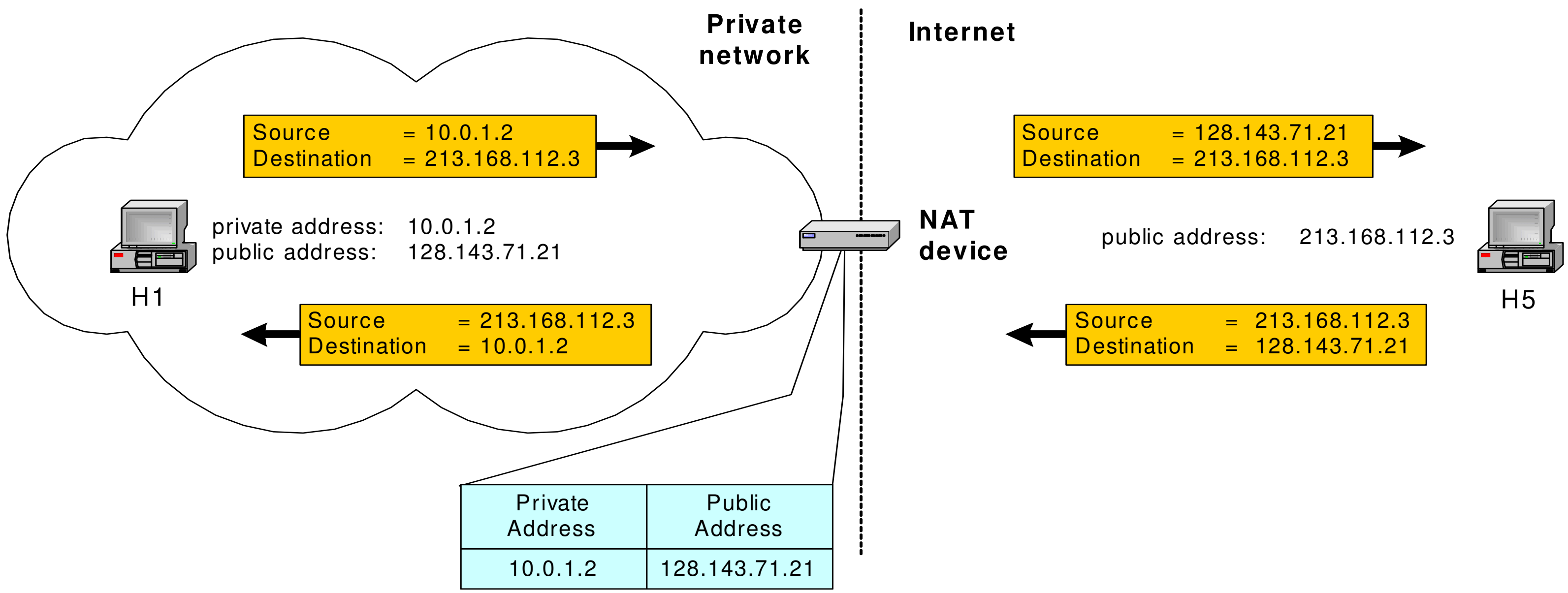
Renato Lo Cigno

Renato.LoCigno@disi.unitn.it

Network Address Translation

- Originally (RFC 1631 - obsolete) a “simple” method for connecting a private network to the public Internet
  - Also called *network or IP masquerading*
- Now (Traditional NAT, RFC 3022) includes also port translation and is more correctly called NAPT: Network Address and Port Translation
  - Payload (application) independent and almost transparent
- NAT evolved and evolves highly intertwined with Firewalls, Routing (a NAT is always also a Router), Traffic Monitoring, and Proxy
  - Often NAT techniques and implementations go beyond RFCs … which follow up
- NAT and NAT traversal evolves in parallel and are intertwined

Basic operation of NAT



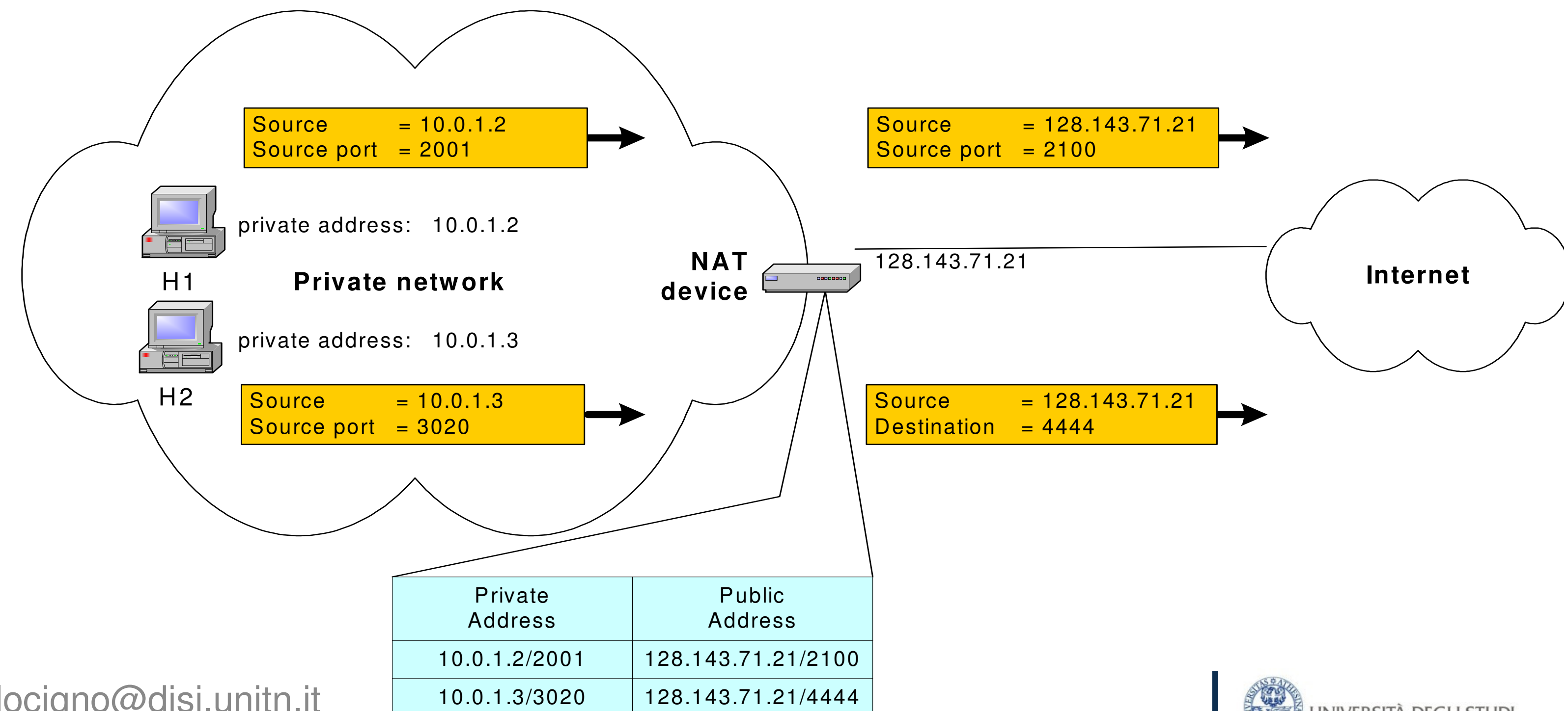
- NAT device must map addresses
- A one-to-one translation brings little advantages
  - Not many public IP "spared" specially if computers are always on

One use of Basic NAT

- **Supporting migration between network service providers**
- **Scenario:** IP addresses are obtained from the service provider. Changing the service provider requires changing all IP addresses in the network.
- **NAT solution:**
  - Assign private addresses to the hosts of the corporate network
  - NAT device has static address translation entries which bind the private address of a host to the public address
  - Migration to a new network service provider merely requires an update of the NAT device. The migration is not noticeable to the hosts on the network
- The same can be done with properly configured DHCP: obsolete use!!

IP masquerading or NAPT

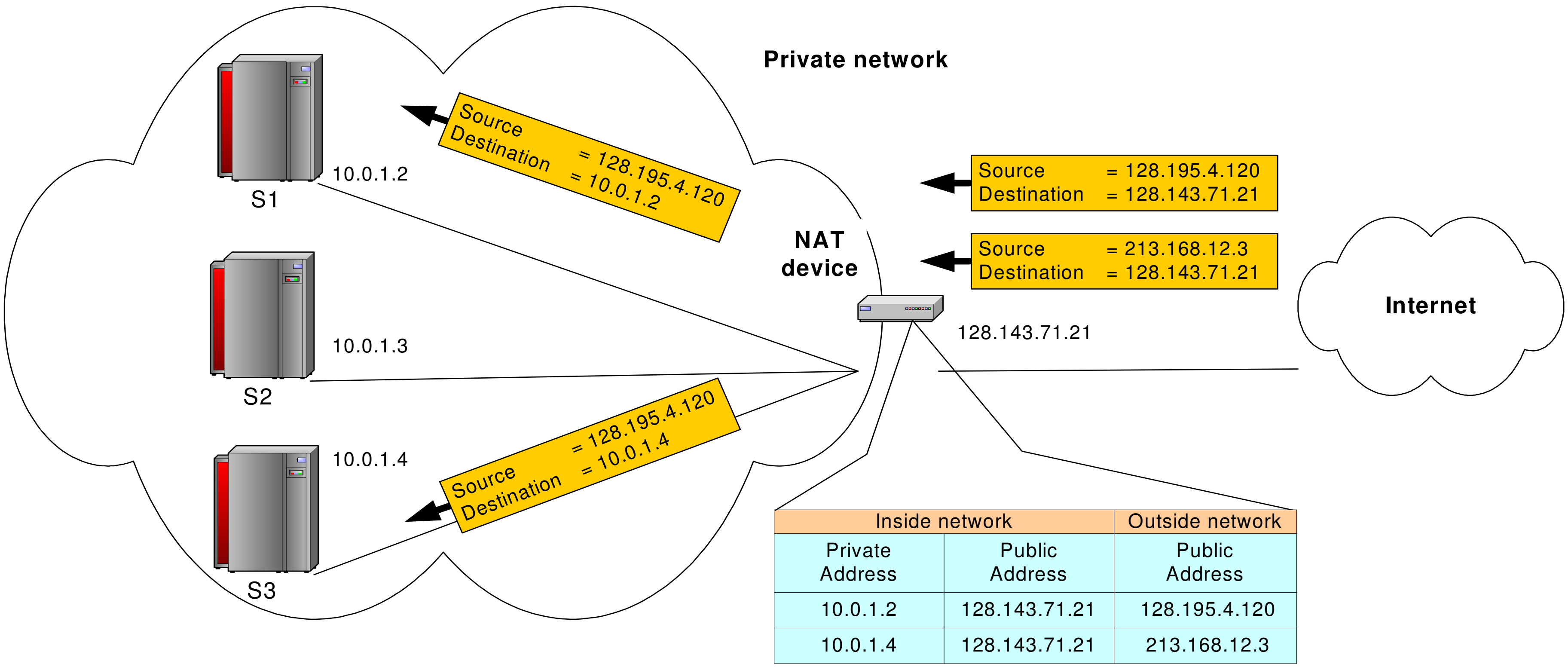
- A single (or few) public IP address is mapped to multiple hosts in a private network
  - Assign private addresses to the hosts of the corporate network
  - NAT device modifies the port numbers for outgoing traffic
  - Ports should be translated as well



Load balancing of servers

- Balance the load on a set of identical servers, which are accessible from a single IP address
  - servers are assigned private addresses
  - NAT device is a front-end for requests to the server from the public network
  - The NAT device changes the destination IP address of arriving packets to one of the private addresses for a server
- Many strategies for assignment
  - Simple round-robin
  - Weighted round robin
  - With feedback from servers on the actual load

Load balancing of servers



Inside network		Outside network
Private Address	Public Address	Public Address
10.0.1.2	128.143.71.21	128.195.4.120
10.0.1.4	128.143.71.21	213.168.12.3

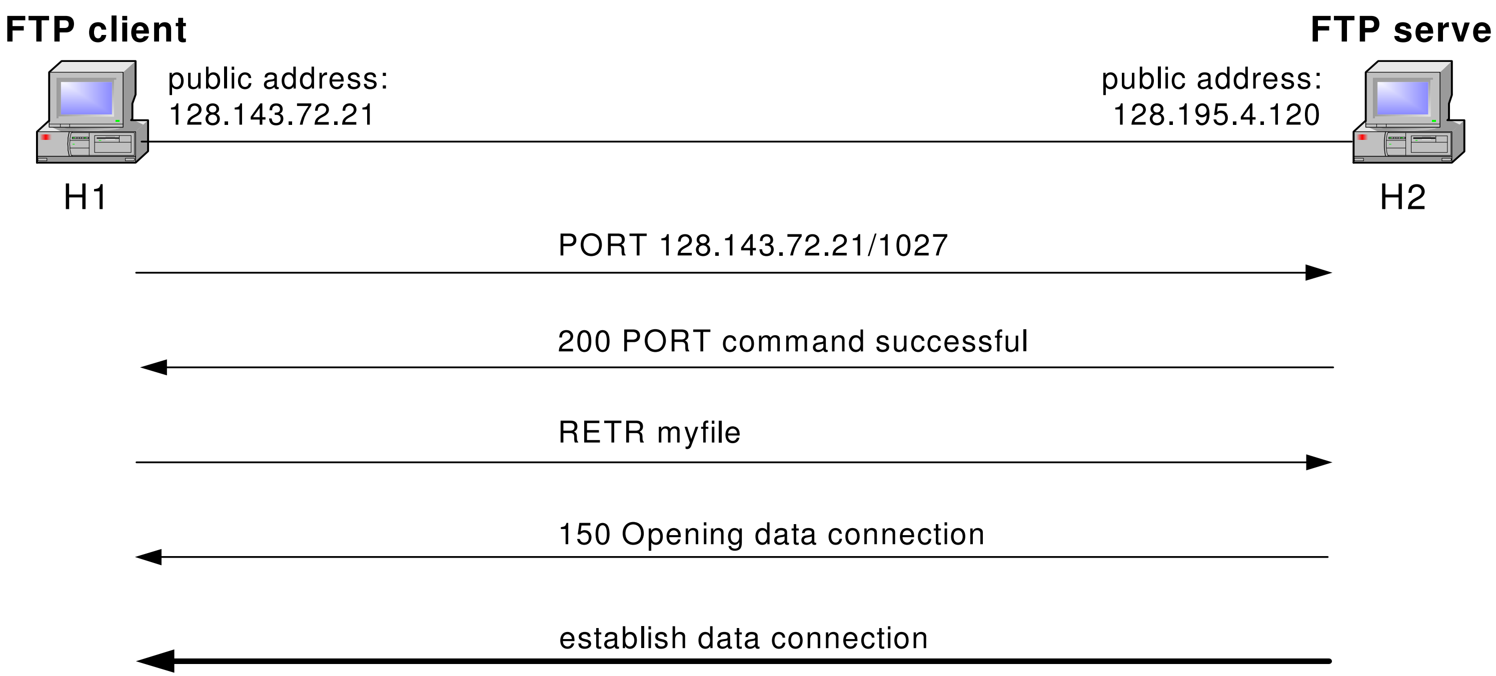
Concerns about NAT

- Changing the IP address requires that NAT boxes recalculate the IP header checksum
- Modifying port number requires that NAT boxes recalculate TCP checksum
- Additional care is needed if a fragmented datagram reaches a NAT device to avoid inconsistent assignments to pieces of the same packet
- End-to-end connectivity:
  - NAT destroys universal end-to-end reachability of hosts on the Internet
  - A host in the public Internet often cannot initiate communication to a host in a private network
  - The problem is worse, when two hosts that are in a private network need to communicate with each other

Further concerns about NAT

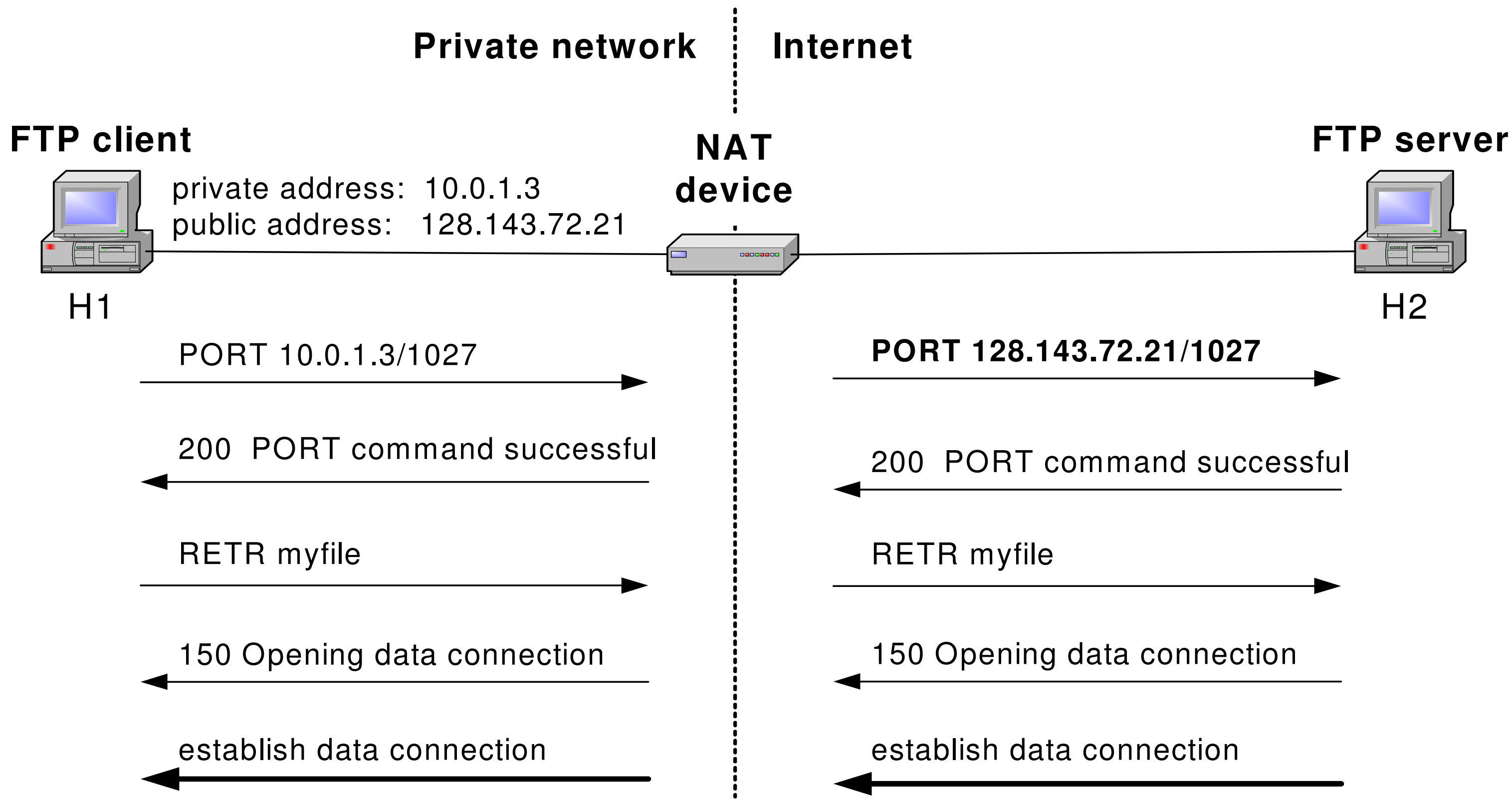
- Applications that carry IP addresses in the payload generally do not work across a NAT
- Some NAT boxes inspect the payload of widely used application layer protocols and, if an IP address is detected in the payload, translate these addresses too
- Typical example is ftp
- Further problems with sftp because the payload is encripted

NAT and FTP



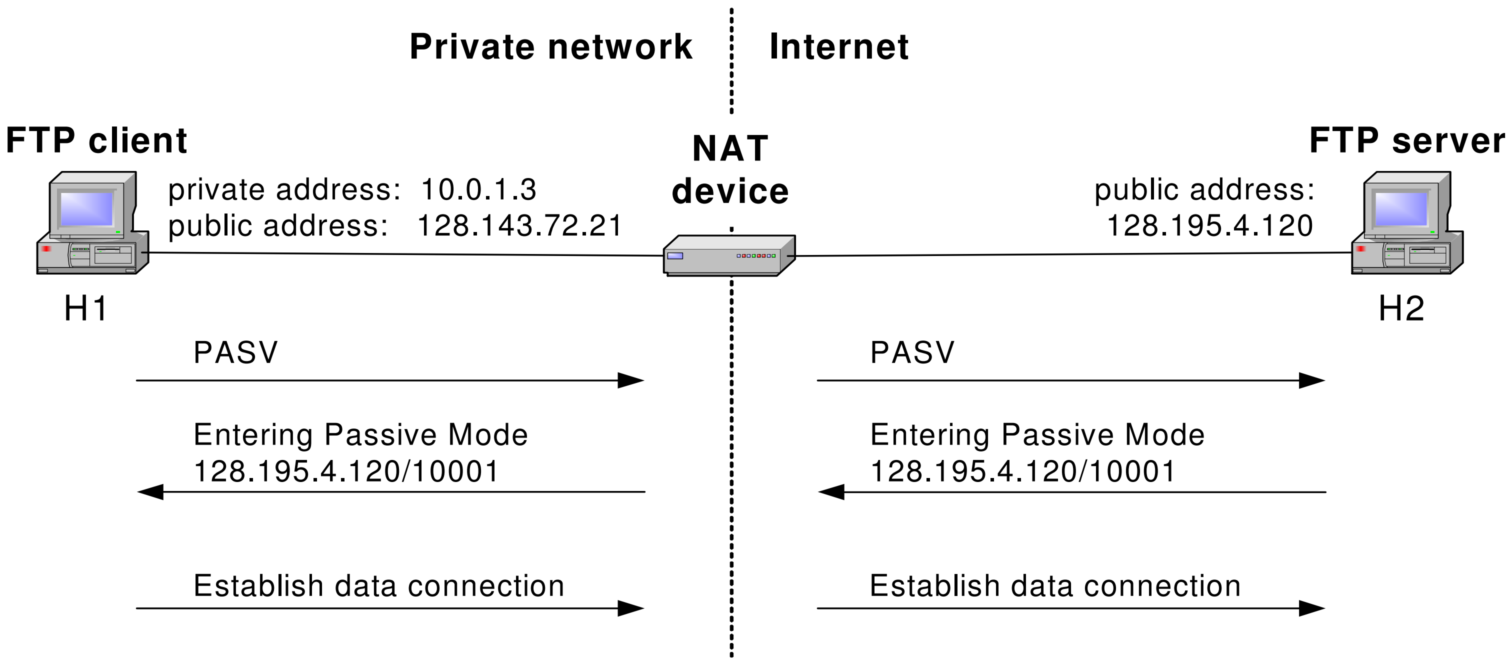
- Normal FTP operation

NAT and FTP



- NAT device with FTP support

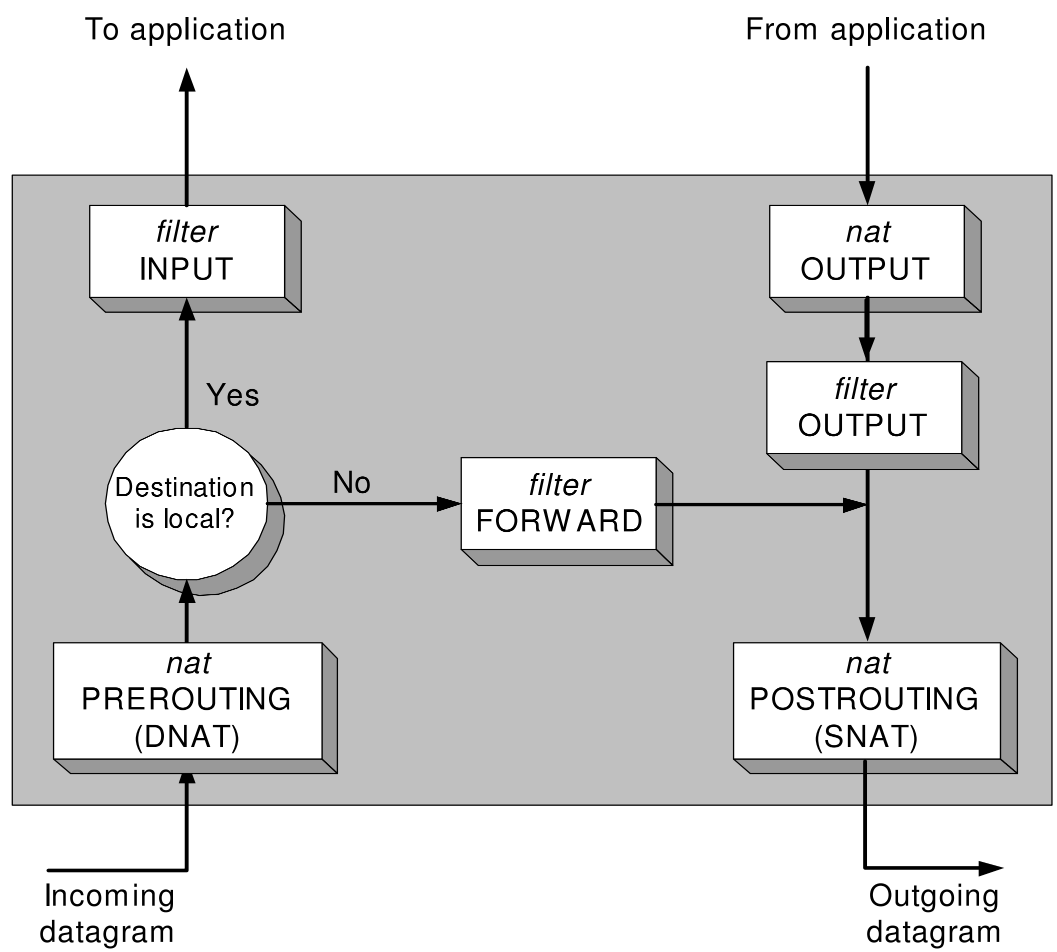
NAT and FTP



- FTP in passive mode and NAT

Configuring NAT in Linux

- Linux uses the Netfilter/iptable package to add filtering rules to the IP module



Iptable based NAT: examples

- **First example:**

```
iptables –t nat –A POSTROUTING –s 10.0.1.2
         –j SNAT --to-source 128.143.71.21
```

- **Pooling of IP addresses:**

```
iptables –t nat –A POSTROUTING –s 10.0.1.0/24
         –j SNAT --to-source 128.128.71.0–128.143.71.30
```

- **ISP migration:**

```
iptables –t nat –R POSTROUTING –s 10.0.1.0/24
         –j SNAT --to-source 128.195.4.0–128.195.4.254
```

- **IP masquerading:**

```
iptables –t nat –A POSTROUTING –s 10.0.1.0/24
         –o eth1 –j MASQUERADE
```

- **Load balancing:**

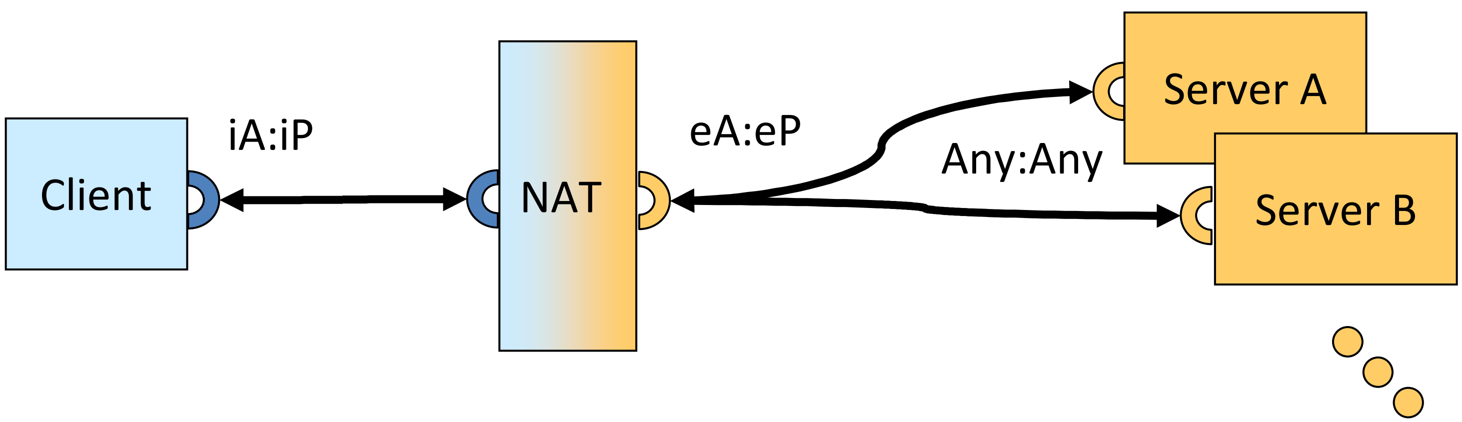
```
iptables -t nat -A PREROUTING -i eth1 -j DNAT --to-
destination 10.0.1.2-10.0.1.4
```

NAT traversal and classification

- Classification of NAT techniques come with methods to traverse NAT boxes
- STUN (Simple Traversal Utility for NAT – RFC3489)
- Same acronym modified to Session Traversal Utilities for NAT in RFC5389
- Universally supports traversal for UDP only
  - RFC5389 supports (with some limits) also TCP and TLC
- STUN is a client-server protocol, with the server on the public side
- STUN servers are identifies via srv records of DNS
  - **`stun`** for UDP
  - **`stuns`** for TCP/TLC

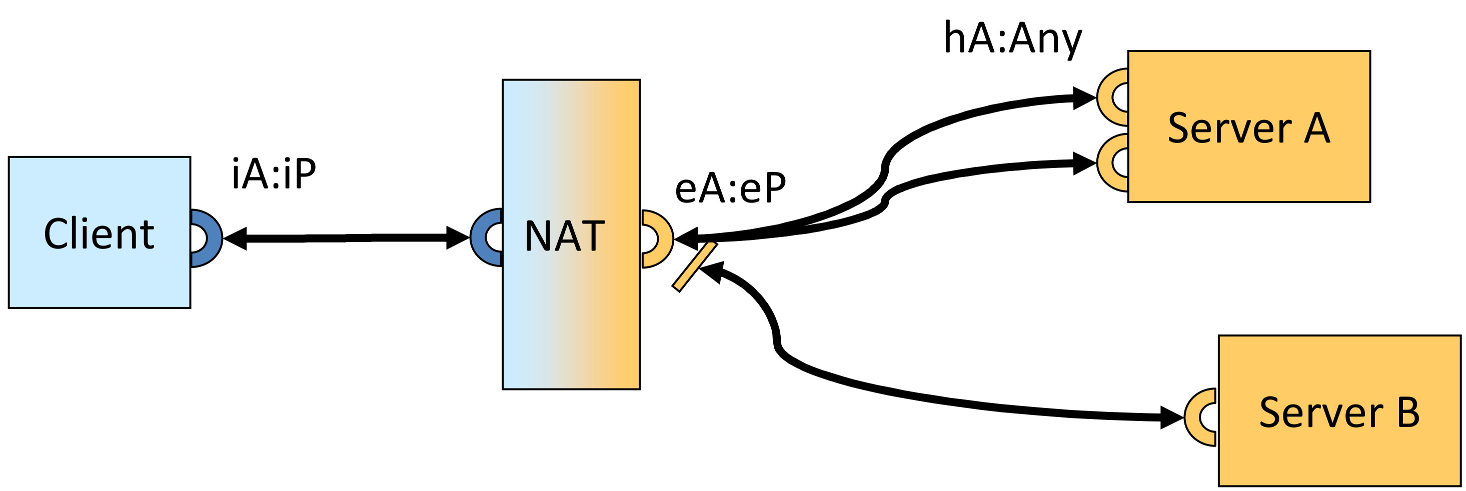
Full-cone NAT

- Known as one-to-one NAT
- Does a semi-static mapping (iAddr:iPort) ↔ (eAddr:ePort)
  - any packets from iAddr:iPort is sent through eAddr:ePort
- External hosts can send packets to iAddr:iPort by sending packets to eAddr:ePort



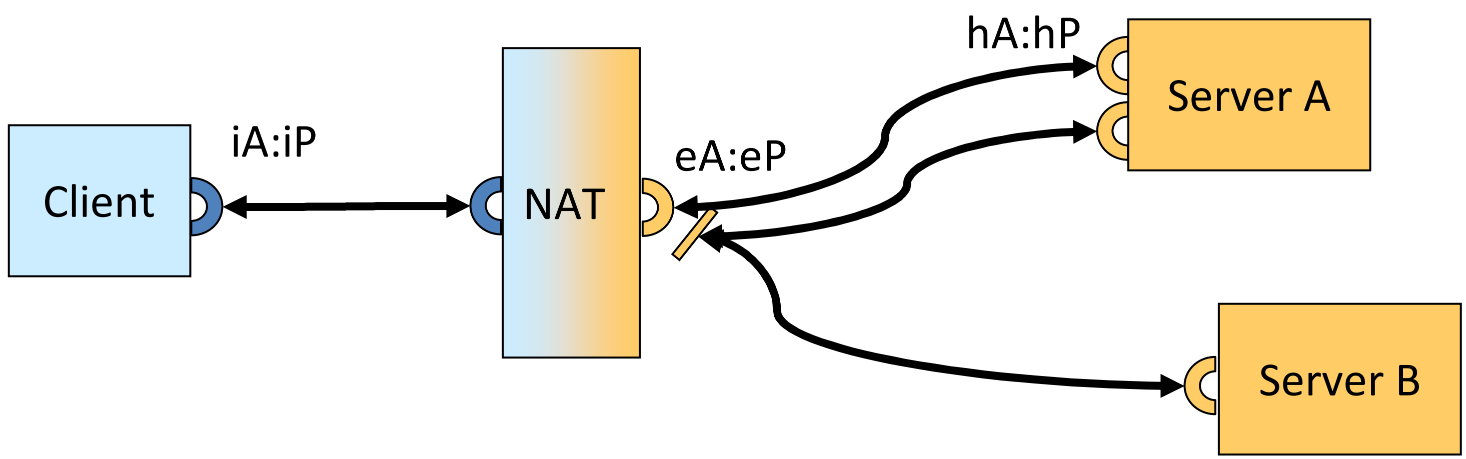
Address-restricted-cone NAT

- Does a semi-static mapping (iAddr:iPort) ↔ (eAddr:ePort)
  - any packets from iAddr:iPort is sent through eAddr:ePort
- An external host (hAddr:any) can send packets to iAddr:iPort by sending packets to eAddr:ePort only if iAddr:iPort has previously sent a packet to hAddr:any
  - The sending (server) port number doesn't matter



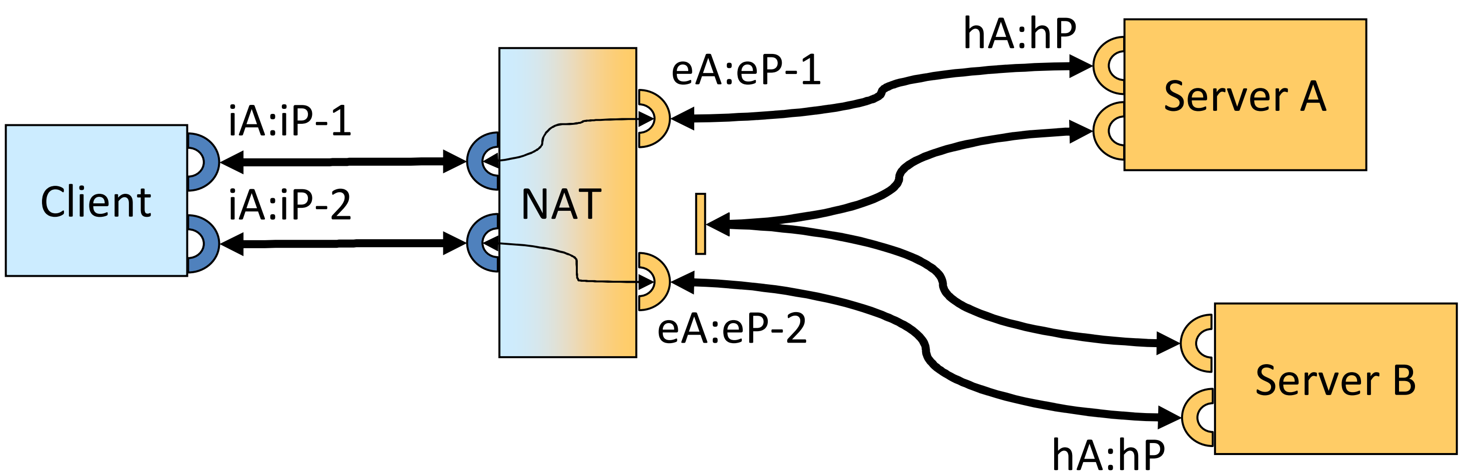
Port-restricted-cone NAT

- Like an address restricted cone NAT, but the restriction includes port numbers
- Does a semi-static mapping (iAddr:iPort) ↔ (eAddr:ePort)
  - any packets from iAddr:iPort is sent through eAddr:ePort
- An external host (hAddr:hPort) can send packets to iAddr:iPort by sending packets to eAddr:ePort only if iAddr:iPort has previously sent a packet to hAddr:hPort



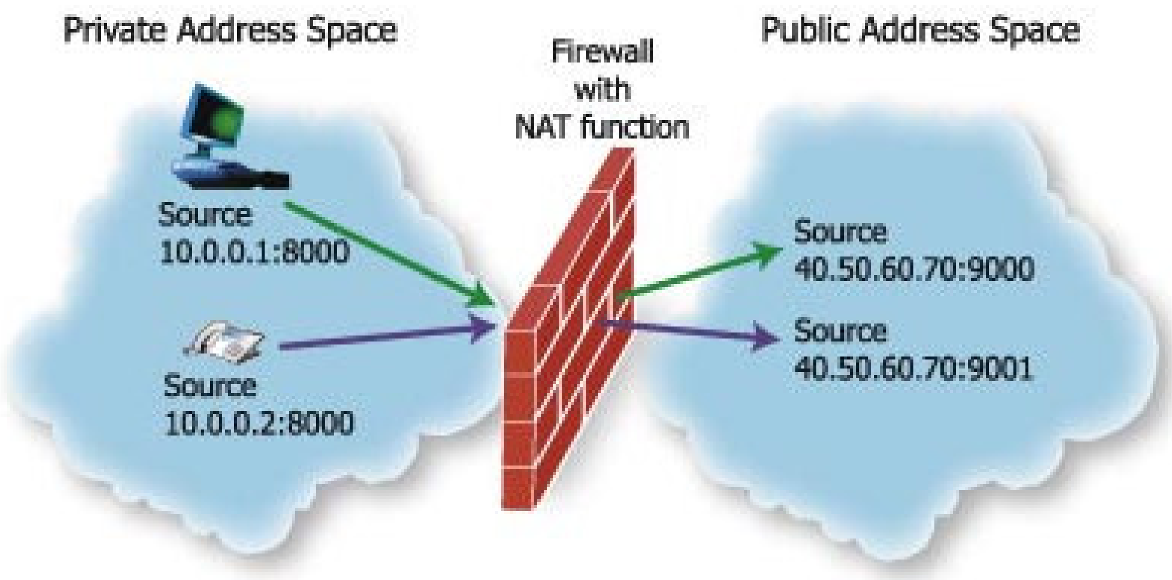
Symmetric NAT

- Packets from (iAddr:iPort) to different (hAddr:hPort) are mapped to different (eAddr:ePort)
  - A host apperas with different (eAddr:ePort) to different hosts!!
- Only an external host that receives a packet from an internal host can send a packet back
  - Strong firewalling, very difficult to traverse



NAT Problems (reprise

- NAT means a 'table' binding private and public addresses and ports
- ‘Bindings' can only be initiated by outgoing traffic
- NAT breaks end-to-end semantics



Source: http://www.newport-networks.com/whitepapers/nat-traversal.html

Methods of solving the ‘NAT Problem’

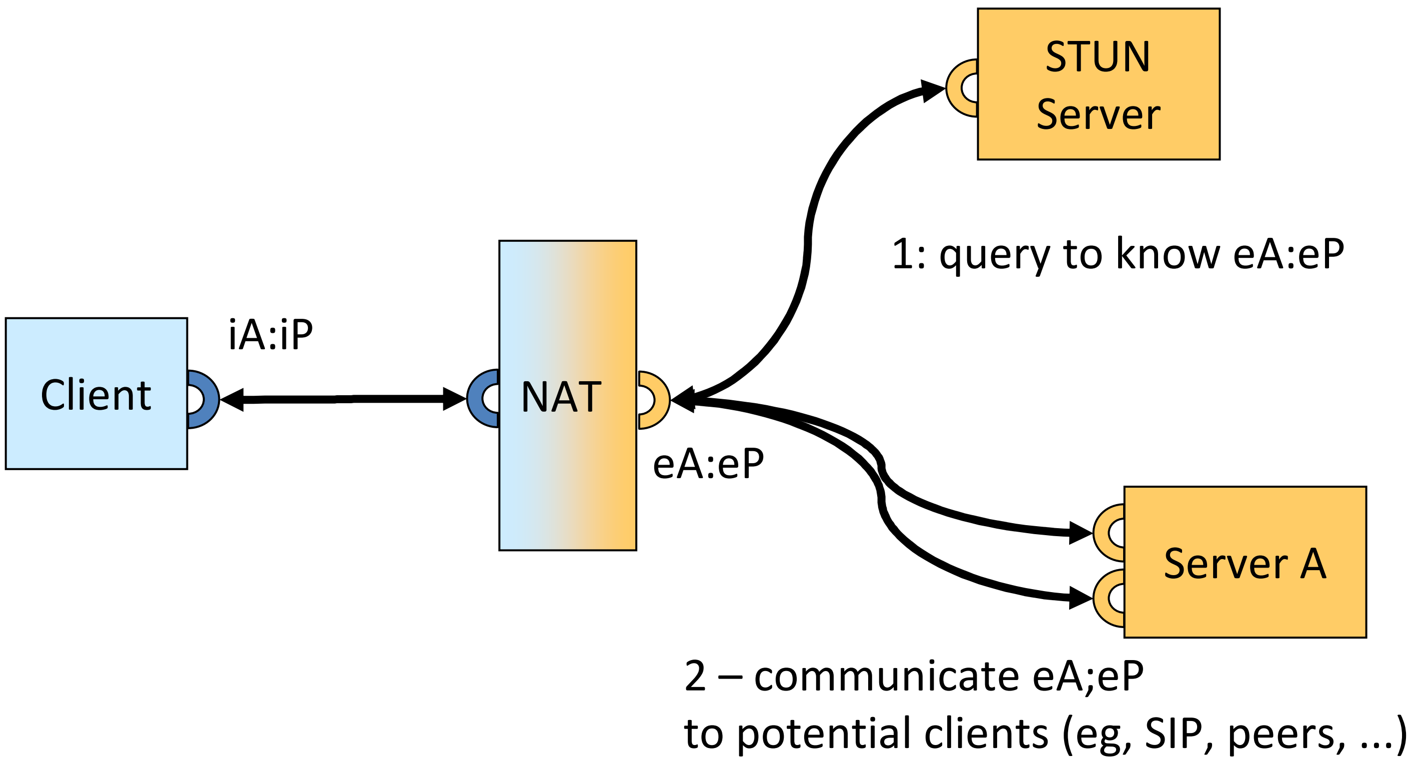
Some proposals for solving NAT traversal are:

- Simple Traversal of UDP Through Network Address Translation devices (STUN)
- Traversal Using Relay NAT (TURN)
- Universal Plug and Play (UPnP)
- Tunnel Techniques

STUN

- Lightweight protocol that allows applications to discover the presence and types of NATs and firewalls between them and the public Internet
- Provides the ability for applications to determine the public Internet Protocol (IP) addresses allocated to them by the NAT
- STUN works with many existing NATs, and does not require any special behavior from them
- A STUN server in the public address space informs STUN-enabled clients of the Public NAT IP address and port being used for that particular session

STUN


STUN
Server
1: query to know eA:eP
iA:iP
Client
NAT
eA:eP
Server A
2 – communicate eA;eP
to potential clients (eg, SIP, peers, ...)

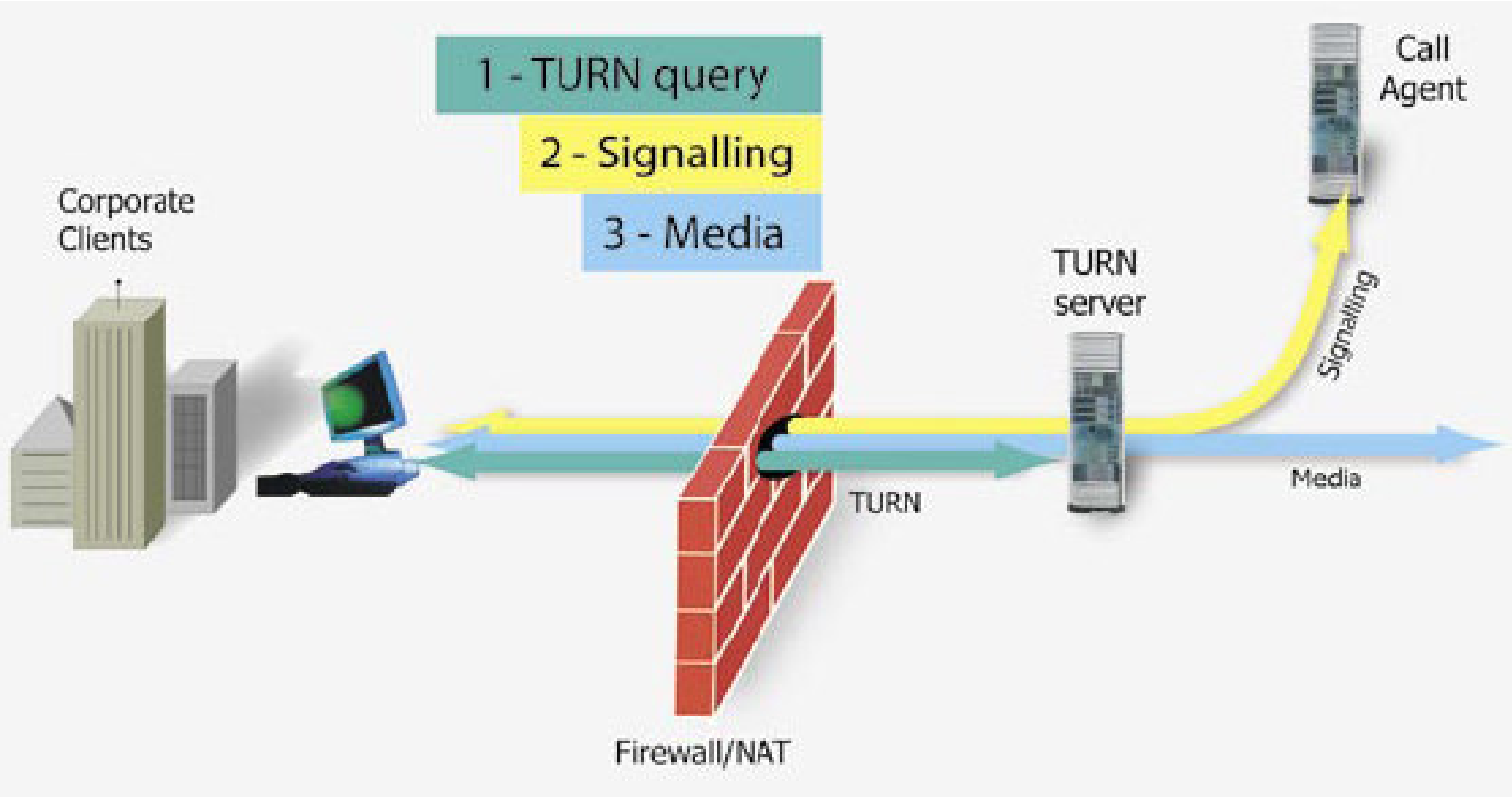
Operation of STUN

- STUN identifies eA;eP by inspecting STUN messages that arrive at the STUN server
- STUN-enabled hosts send an exploratory message to the external STUN server to determine the transmit and receive ports to use
- The STUN server examines the incoming message and informs the client which public IP address and ports were used by the NAT
- These are communicated to e.g.
  - SIP proxies/buddies in the call establishment messages

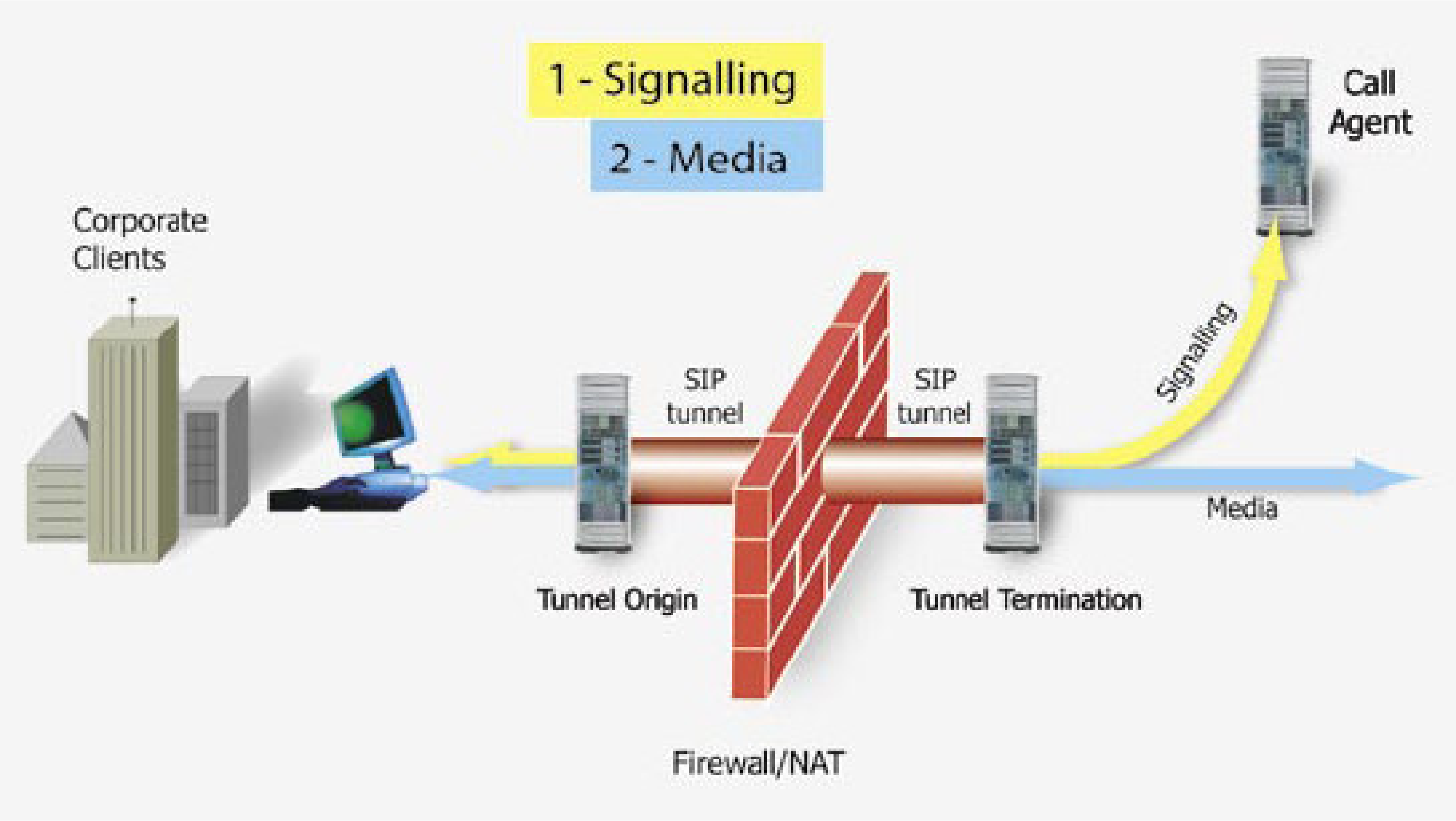
TURN - Traversal Using Relay NAT

- TURN relies on a "counter" middlebox that is inserted in the communication path
- A TURN server is located
  - in the campus DMZ
  - in the Service Provider network
- A TURN-enabled client sends initial messages to the TURN server
- The TURN server will forward the traffic reverting the NAT operation
- This information is used e.g.
  - in the SIP call establishment messages and for subsequent media streams
  - in P2P gossipping messages
- Works with symmetric NAT
  - No change in the destination address seen by the NAT
  - Heavy protocol!!
  - Can be used as a second resort
  - See also ICE (Interactive Connectivity Establishment)

TURN setup


1 - TURN query
2 - Signalling
3 - Media
Call
Agent
Corporate
Clients
TURN
server
Signalling
Media
TURN
Firewall/NAT

Tunnel Techniques



Tunnel Techniques

- A tunnel can be used to cross any Firewall/NAT
- The tunnel termination can be anywhere
- The Tunnel can be also secure (see IPSec)
- Can even be used to anonymize communications (see Onion Routing and Tor)
- Blocking tunnels is diffcult
  - impossible if they are TLS